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DEPARTMENT OF COMMERCE
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RUBBER CEMENTS

Introduction

This letter circular has been prepared as an answer to inquiries about the composition, preparation and uses of rubber cements. In so far as possible the information here given is presented from the standpoint of the individual, not expert in rubber technology, who wishes to employ a rubber cement for some particular purpose.

Rubber cement is ordinarily understood to be a solution of rubber, in gasoline, benzene, carbon tetrachloride or other organic solvent with or without accessory ingredients. Within recent years, however, rubber latex and preparations made from it have come to be used for many of the same purposes as the above-mentioned cement and are sometimes called rubber cements. These products will be treated briefly in the present paper, but to avoid confusion they will be designated as latex cements, and the term rubber cement will be used to mean solutions of rubber in gasoline or other non-aqueous solvents.

Both rubber and latex cements, as the names imply, are used as adhesives, but they are also employed extensively for other purposes such as for binding and sealing compounds, for applying rubber coatings to various materials, and for making products such as gloves and toy balloons by the dipping process.

There are many types of cements and practical applications for cements which cannot be described in the limited scope of this letter circular. The reader seeking additional information will find it profitable to consult publications listed in the bibliography, section VIII, of this paper.

CONTENTS

I. INGREDIENTS OF RUBBER CEMENTS

The essential ingredients of a rubber cement are rubber and solvent. To these may be added sulphur and accessory ingredients for vulcanization, antioxidants, pigments, and other materials as required for special purposes.

Commercial sources of rubber, solvents, and other ingredients are listed in section VII.

1. Rubber

The rubber commonly used for cements is the ordinary raw, or crude rubber of commerce, which comes to the market chiefly in the form of crepe or ribbed smoked sheets. "Number 1 thin latex crepe" is used where a light colored cement is desired - otherwise either crepe or smoked sheets may be employed. Some specifications for cements call for certain kinds of wild rubber, especially for "fine up-river Para rubber". There is, however, little evidence that such cements are superior for general use to cements made from the crepe or smoked sheets which are produced on plantations. A percentage of a tacky African rubber is sometimes used with other rubber to increase the tackiness of the resulting cement. Particular attention is directed to the fact that the rubber used for cements must be raw, or as it is called by the trade, crude rubber. Manufactured rubber articles such as inner tubes, gloves, rubber bands, and the like have been vulcanized and are insoluble in all rubber solvents. There is no practical means of making a satisfactory cement from vulcanized rubber.

2. Solvents

The common solvents used in making rubber cement are gasoline, benzol and carbon tetrachloride.

Gasoline is the standard solvent for rubber so far as American practice is concerned. It is employed in grades having different rates of evaporation depending on the type of cement to be made. For cement to be used for adhesive purposes one authority recommends a grade boiling in the range 65 degrees to 128 degrees C. (149° to 262° F.). A grade boiling in the range 67 degrees to 140 degrees C. (152° to 284° F.) is recommended for cement that is to be spread on fabric. Gasolines of a lower initial boiling point than 65 degrees C. are looked upon with disfavor for cement purposes because of lesser solubility of the rubber, larger losses by volatilization in making and handling the cement, and "blushing" of the cement when applied as the result of condensation of moisture. Gasolines containing high boiling or difficultly volatile fractions are objectionable because cements made from them dry slowly and may be mechanically weak on account of the presence of residual oils. Most motor gasolines are unsatisfactory in this regard for use as rubber solvents. Some high test and aviation gasolines may be used as rubber solvents with satisfactory results, but in general it will be found

advantageous to employ a grade of gasoline designed for solvent purposes.

Benzol is generally regarded as being a better solvent for rubber than gasoline, in that it softens and dissolves rubber more readily than gasoline and gives a cement that is smoother and of more uniform consistency. Benzol is a definite chemical substance having a boiling point of 80 degrees C. and constant physical properties. When used in a cement it has the advantage that it evaporates at a uniform and rapid rate, and that it leaves no oily residue to weaken the rubber film obtained from the cement. Impure benzols contain a higher boiling homolog, toluol, as the chief impurity. This decreases the rate of evaporation somewhat but it is not possible to secure with benzol the same range of volatility that can be obtained with gasolines.

Carbon tetrachloride is similar to benzol as a solvent for rubber. It is a definite chemical substance and when pure has the boiling point, 76 degrees C. The outstanding advantage of carbon tetrachloride over both benzol and gasoline is the fact that it is non-flammable.

Both benzol and carbon tetrachloride would be more widely used in industry than is now the case were it not for the fact that <u>they are toxic when inhaled as vapor or brought into contact with the skin</u>. The susceptibility to poisoning from these substances varies greatly with the individual but <u>neither should be used without adequate ventilation and reasonable care to avoid contact of solvent or cement with the skin</u>.

3. "<u>Solvent Activators</u>"

A solvent activator is a substance which increases the fluidity of solutions of rubber. Although rubber and solvent can be blended in any desired proportion, such mixtures become too stiff for practical use as cements with relatively low percentages of rubber. A solvent activator will increase the amount of rubber that can be incorporated in a cement which is being made to a given consistency, or will increase the fluidity of a cement containing a given percentage of rubber.

At the present time the only solvent activator on the market of which we have a record is a preparation of unrevealed composition sold under the trade name, "Bondogen". It is designed for use in rubber gasoline cements. For detailed information regarding this product, the reader is referred to the R. T. Vanderbilt Co., 230 Park Avenue, New York, N. Y.

4. <u>Vulcanizing Agents</u>

Rubber cements may be vulcanized either with sulphur, or with certain organic compounds containing sulphur, or with sulphur chloride.

Any form of powdered sulphur is satisfactory for use in

rubber cements. Flowers of sulphur and ground roll sulphur are the forms most commonly available.

Sulphur is seldom used alone as a vulcanizing agent on account of the relatively long time and high temperature needed for vulcanization. Certain complex organic substances known as accelerators are commonly used to speed up the vulcanizing process. These will be discussed more fully in a subsequent section in which formulas are given.

Accelerators usually require the addition of zinc oxide to function properly. Zinc oxide for this purpose should be the dry powder, and not the linseed oil paste used in paints. The addition of stearic acid may also be advantageous.

Certain complex organic compounds containing sulphur function both as accelerators and vulcanizing agents. These will be described in connection with particular formulas.

Sulphur chloride, more properly termed sulphur mono-chloride, is a yellow, ill-smelling, corrosive liquid capable of vulcanizing rubber quickly in the cold. As a vulcanizing agent for cements and thin layers of rubber it is commonly employed as a 2 percent solution in anhydrous carbon tetrachloride or carbon bisulphide.

5. Antioxidants

Antioxidants are substances added to rubber to minimize the rate of deterioration. It is often advantageous to incorporate them in cements that are to be used for work for which a reasonable degree of permanence is desired.

II. ORDINARY OR NON-VULCANIZING CEMENTS

The simplest rubber cement consists of crude rubber in a solvent. The ease with which the rubber will dissolve and the quality of the resulting cement depend upon the amount of milling or "break-down"[1] which the rubber receives prior to being placed

[1] Crude rubber as received commercially is a tough, gristly material and when in this condition it is difficult to incorporate other ingredients with it. The first process in mixing a rubber compound is usually to "break-down" or soften the rubber by working it between steel rolls on a rubber mill or between the blades of a mixer. The rolls or blades are arranged so that they may be heated or cooled.

in the solvent. If the rubber is not milled at all, it is very reluctant to go into solution and the resulting cement is non-homogeneous and will contain a low percentage of rubber (although quite stiff). Rubber which is milled a great deal, particularly on cold rolls, will dissolve very readily. The cement which results, however, is poor from the standpoint of adhesive qualities. It has a consistency somewhat like molasses

with very little "tack". The best cement is produced when the rubber is given a small amount of hot milling just sufficient so that a reasonable amount, say 10 percent, may be put in solution.

This solubility of rubber may be changed as indicated in section I - 3 with a solvent activator. By the use of about 2 percent of Bondogen in gasoline, it is possible to make a cement containing 5 percent of rubber which has not been milled at all. However, the most important use for the activator is not for dissolving unmilled rubber but (1) to facilitate putting milled rubber in solution, (2) to increase the amount of rubber which can be put into a solution of given consistency, and (3) to decrease the consistency of a cement of any given rubber content.

Small amounts of cement may be made by placing 8 to 10 percent of milled rubber in a solvent and allowing it to swell for several hours. Occasional shaking or stirring after that period will yield a uniform cement in two or three days. Mechanical stirring will hasten the process.

Non-vulcanizing cements are used where a very strong bond is unnecessary. They are not suitable for use where the parts may become hot as the cement will soften.

III. VULCANIZING CEMENTS

With a vulcanizing cement a permanent bond can be made between most rubber surfaces and between certain other surfaces. Two types are described (1) heat vulcanizing cements and (2) cold curing cements vulcanized with sulphur chloride.

1. Heat Vulcanizing Cements

The basic constituents of heat vulcanizing cements are rubber, sulphur, an accelerator and usually an accelerator activator such as zinc oxide. The accelerator is used to increase the rate of vulcanization and avoid the necessity for prolonged heating. The time required for vulcanization is greatly affected by the amount of sulphur, the kind of accelerator used and the temperature employed. To illustrate the wide range of vulcanizing conditions, a cement containing simply rubber and sulphur would vulcanize in about two hours at a temperature of 288 degrees F. The addition of certain accelerators may reduce the required time to as little as one or two minutes. In general, however, when very active accelerators are used, it is more practicable to use a little longer time than this for vulcanizing at a lower temperature. Cements can be made which will vulcanize in fifteen minutes or less in boiling water.

If a cement will vulcanize at a sufficiently low temperature, it is often referred to as self-vulcanizing. This is not an exact term, however, as the temperature has a great influence on the time of vulcanization and a cement which will vulcanize in a few days in Summer might not vulcanize at all at Winter temperatures.

Heat vulcanizing cements are applied by spreading one or more coats of cement on the parts to be united, allowing the solvent to evaporate, pressing the parts together, and holding them under pressure while being heated at the vulcanizing temperature. After the cement is vulcanized, it is not dissolved by the solvents which dissolve unvulcanized rubber and is little affected by moderate temperatures.

2. Cold Curing Cements Vulcanized With Sulphur Chloride

If sulphur mono-chloride is in contact with rubber, vulcanization takes place in a very short period of time. A common way of using sulphur chloride for cementing is to give the parts to be united one or more coats of a non-vulcanizing cement. After the solvent has evaporated, a solution of 2 percent of sulphur chloride in a solvent is applied, the parts quickly put together and held under pressure for a few minutes. No heat is necessary.

The use of sulphur chloride in the manufacture of dipped goods is described in section V - 4.

A rapid vulcanizing cement may be also made by adding with care a very small percentage of sulphur chloride directly to a non-vulcanizing cement. The amount added determines the time required for vulcanization. An example of such a cement is as follows:

> Dissolve 10 ounces of rubber in 100 fluid ounces of benzol. Add 5 fluid ounces of a 2 percent solution of sulphur chloride in benzol and immediately mix thoroughly.

This cement must be used soon after being mixed as it will "jell" or vulcanize and become worthless in about an hour.

In vulcanizing with sulphur chloride a more careful control of the procedure is necessary than with other types of cements.

3. Typical Formulas

Following are some typical formulas for rubber cements together with information on their vulcanizing characteristics.

Cement No. 1. (Vulcanizing)

Ingredients	Parts by weight
Rubber	100
Sulphur	4
Zinc oxide	5
Zinc stearate	1
Diphenylguanidine	1
Benzol (or other solvent)	1000

A film of rubber deposited from this cement will vulcanize in 30 minutes at 288 degrees F. Other accelerators may be substituted for diphenylguanidine such as diorthotolylguanidine or mercaptobenzothiazole.

Other materials are often added to cements as for instance, stearic acid as an added activator, antioxidants to improve aging qualities and mineral fillers for specific purposes.

Cement No. 2. (Self Vulcanizing)

Ingredients	Parts by weight A	B
Rubber - - - - - - - - - - - - - -	50	50
Sulphur - - - - - - - - - - - - -	4	--
Zinc stearate - - - - - - - - - -	2	--
Antioxidant (See end of section III)	1	--
"Zimate" (See end of section III)	--	1
"Captax" (" " " " ")	--	1
Benzol (or other solvent) - - - -	500	500

This cement is made in two parts (A and B) in order to prevent premature vulcanization. Before using, mix together equal parts of A and B. The mixture of A and B can ordinarily be kept for several days but it tends to vulcanize or "jell" and become worthless if kept longer.

A film of rubber from this cement will vulcanize in boiling water in about 15 minutes. It will self-vulcanize in time at room temperature.

Cement No. 3. (Self Vulcanizing)

Ingredients	Parts by weight A	B
Rubber - - - - - - - - - - - - -	50	50
Sulphur - - - - - - - - - - - -	4	--
Zinc oxide - - - - - - - - - - -	2	--
Zinc stearate - - - - - - - - -	1	--
Antioxidant - - - - - - - - - -	1	--
Accelerator 552 - - - - - - -	--	1.5
Benzol (or other solvent) -	500	500

This cement is made in two parts and used the same as cement No. 2. Its vulcanizing characteristics are similar to cement No. 2.

Cement No. 4. (Self Vulcanizing)

Ingredients	Parts by weight A	B
Rubber - - - - - - - - - - - - - - -	50	50
Zinc oxide - - - - - - - - - - - - -	5	--
"Tetrone A" - - - - - - - - - - - -	--	2
Benzol (or other solvent) - - -	500	500

With this cement active sulphur is contained in the accelerator and no additional sulphur is necessary.

The cement is made in two parts which are used the same as cement No. 2. Its vulcanizing characteristics are similar to cements Nos. 2 and 3.

Cement No. 5. (Self Vulcanizing)

Ingredients	Parts by weight A	Parts by weight B
Rubber	50	50
Sulphur	5	--
Zinc stearate	2	--
Antioxidant	1	--
"Captax"	--	2
"Tetrone A"	--	2
Benzol (or other solvent)	500	500

This cement contains an excess of sulphur and a combination of accelerators in order to produce very rapid vulcanization. It is made in two parts and used the same as cements Nos. 2, 3 and 4. A film of rubber from this cement will vulcanize in boiling water in about 7 minutes. It will self-vulcanize at room temperature.

4. Making Rubber Cements

The method of making a rubber cement consists of first making a rubber stock by mixing rubber with the various ingredients on a rubber mill or in an internal mixer. In the case of self-vulcanizing cements such as those listed, the two parts should be mixed separately. After mixing, the rubber stocks are put in solution by first allowing them to swell in a solvent for several hours and then stirring or shaking until a uniform mixture is obtained.

It is possible to mix cements containing small amounts of fillers more or less satisfactorily by placing the fillers with the rubber directly in a solvent. Better dispersion is obtained, however, by mixing rubber compounds as described.

After a cement is made, it should so far as possible be protected from light and also, of course, from exposure to the air. A cement which is exposed to light deteriorates quite rapidly and decreases greatly in consistency due to oxidation of the rubber.

5. Accelerators and Antioxidants

Captax = Mercaptobenzothiazole sold under the trade-name "Captax" by the R. T. Vanderbilt Co., New York.

Zimate = Oxidized salt of dithiocarbamic acid sold under

the trade-name of "Zimate" by the R. T. Vanderbilt Co., New York.

Accelerator 552 = Piperidine-pentamethylene-dithiocarbamate sold under the trade-name of "Accelerator 552" by the E. I. du Pont de Nemours Co., Wilmington, Delaware.

Tetrone A = Dipentamethylenethiuramtetra sulphide sold under the trade-name of "Tetrone A" by E. I. du Pont de Nemours Co., Wilmington, Delaware.

Diphenylguanidine and Diorthotolylguanidine, ordinarily referred to as D.P.G. and D.O.T.G., are sold by most supply houses dealing in rubber chemicals.

"Vandex" is a trade-name for selenium. It is sold by the R. T. Vanderbilt Co., New York.

Antioxidants - Many different antioxidants are available. One which is used extensively is phenyl-beta-naphthylamine. This is sold under the trade-name of "Agerite Powder" by the R. T. Vanderbilt Co., and under the trade-name of "Neozone D" by the E. I. du Pont de Nemours Co.

IV. LATEX CEMENTS

Rubber latex is the milk-like product obtained by tapping the rubber tree, and consists essentially of a dispersion of extremely small rubber particles in a watery medium. It usually has a higher rubber content than rubber cement but is much less viscous than the cement. As received in this country it contains about 3 percent by weight of concentrated aqueous ammonia as a preservative. Rubber latex finds many of its applications by reason of the fact that it has an aqueous medium and hence gives off no flammable or toxic fumes on drying. Artificial latex can be made from either crude or reclaimed rubber, and is used industrially to some extent. Rubber latex is a cement itself and may be used in the same manner as a non-vulcanizing cement by applying it and allowing the water to evaporate. It ordinarily contains 30-40 percent of rubber while the usual solvent cement contains about 10 percent so that the amount of rubber left from solution will be proportionately greater for latex.

It is possible to make a vulcanizing cement from latex by adding sulphur and an accelerator. All added materials, however, must be soluble in water or properly dispersed in it as a fine suspension.

The following is given by one authority as a formula for a latex cement:

Formula No. 6. (Latex Cement)

Ingredients	Parts by weight
Rubber latex (33% rubber content) ----	300
Zinc oxide -------------------	1
"Zimate" (See end of section III) ----	1
"Captax" (" " " " ") ----	1
Sulphur -------------------	1
Antioxidant ------------------	1

Before adding the ingredients to the latex they should be ground for 12 hours or more in a ball mill with water. Less sulphur and zinc oxide are needed than in a corresponding rubber cement (formula No. 2).

Care must be observed in adding ingredients to rubber latex so as not to cause the rubber to coagulate.

A rubber film deposited from this latex cement vulcanizes readily in boiling water. It is stated that it will vulcanize in 15 minutes in an oven at 175 degrees F.

While normal latex contains 30 to 40 percent of rubber, it has been found possible to remove a portion of the water and by adding certain materials to prevent coagulation, to produce a latex containing as much as 75 percent of rubber.

There has come into the market recently a vulcanized latex. This consists of ordinary latex in which the rubber particles have been vulcanized by chemical means. Simple evaporation of the water from this material leaves a vulcanized rubber.

This product requires no mixing or compounding and needs no heating or other treatment after application. From the standpoint of simplicity and convenience it leaves little to be desired.

There are many patents relating to rubber latex and anyone utilizing this material should give consideration to the patent situation.

V. USES OF RUBBER AND LATEX CEMENTS

1. Adhesives

(a) Rubber to Rubber

One important use for cement as an adhesive is for a bond between rubber surfaces, as in the manufacture of many rubber products such as boots and shoes, hospital supplies, tires and tubes to some extent, and many hand made articles. Also the use of rubber cement as an adhesive between rubber surfaces is important in repair work as for instance in the repair of tires and tubes.

When using cement for repair purposes, the preparation of the surfaces to be cemented is quite as important as the cement used. In putting a patch on an inner tube, the portions to be cemented should be well roughened using coarse sandpaper or a metal scraper. They should then be given two or more thin coats of cement allowing each to dry. The best patches are made from vulcanized sheet rubber coated on one side with a layer of unvulcanized rubber - the unvulcanized side being placed next to the tube. The patch should be held on the tube with a clamp and the whole heated to cause vulcanization. The same general procedure is followed with other types of repairs. If a self-vulcanizing cement is used and it is not feasible to heat the article, the parts should be clamped together and held under pressure until vulcanization takes place. In case of a patch on an inner tube, pressure can be applied by inflating the tube in the casing.

(b) Rubber to Textiles

Good adhesion can be obtained between rubber and cotton and between rubber and some other textiles. It is common practice to first "friction" the fabric, or in other words, force rubber into the meshes of the fabric. This is done on a friction calender.* A substitute for frictioning consists of running the fabric through a bath of rubber or latex cement.

Either of these methods leaves the meshes of the fabric filled with rubber so that with further coating the adhesion is really between rubber surfaces and the process may be carried out the same as a rubber to rubber adhesion.

(c) Rubber to Leather

Adhesion between rubber and leather cannot be made as easily as between rubber and cotton because of the character of the leather and because leather cannot be heated to the usual vulcanizing temperatures.**

It is quite common to use cements which will self-vulcanize without heating above room temperature. The desirability of making the leather surface to be cemented very rough and fuzzy before applying the cement cannot be emphasized too much.

NOTES:-

*Calenders are described briefly in Bureau of Standards Circular No. 38, The Testing of Rubber Goods.

**In a recent patent, #1,719,101, a method of vulcanization of rubber to leather by heat is claimed to have been discovered.

Rubber soles for cementing to leather soles have become popular in the past few years. In one type, the sole is coated when received with a layer of tacky rubber and the cement which accompanies it appears to be non-vulcanizing. In another type, the bond is made by the equivalent of a two part vulcanizing cement. The sole is coated when received with one part of cement as for instance, formula 5A in section III (the solvent of course having evaporated). The cement accompanying the sole is equivalent to formula 5B. The two parts (5A and 5B) come into contact in putting on the sole and vulcanization gradually takes place.

(d) Rubber to Metals

In general, rubber does not adhere easily to metals, but by using certain combinations of metal and rubber, satisfactory adhesion can be secured. Rubber does adhere fairly well to brass and in particular to brass of a composition of approximately 75% copper and 25% zinc. The following cement formula is given by one authority as a cement for rubber to brass:

Cement No. 7. (Rubber to Brass)

Ingredients	Parts by weight
Rubber	100
Antioxidant (See end of section III)	1
Stearic acid	1
Zinc oxide	5
Carbon black	40
Sulphur	5
"Vandex" (See end of section III)	0.5
"Captax" (" " " " ")	1
Solvent	1000

This cement requires about 30 minutes at 288 degrees F. for vulcanization.

If adhesion is desired between rubber and steel, the steel may first be plated with brass and then treated the same as though it were solid brass.

Another method of securing adhesion between steel and rubber is by the use of a thermoprene cement. This material is of a different class from others described in this circular. It is derived from rubber by the action of certain reagents such as phenol sulphonic acid. (See section VIII for references on this product). The basic patents on this cement are held by the B. F. Goodrich Company of Akron, Ohio. The cement which they produce for uniting rubber to metals is designated by the trade-name of "Vulcalock".

There are several other methods for securing adhesion between rubber and metals and many patents covering special materials and processes. References to some of these are listed

in section VIII.

2. Binders

A rubber or latex cement is often used as a binder for other materials. For instance, many packings made principally of asbestos fibre contain rubber as a binder; some brake lining compositions employ rubber for this purpose; and in the shoe industry it is used as a binder for felt and cotton insoles.

3. Sealing Compounds

One of the large uses for latex cement is as a sealing material in the manufacture of "tin" cans. The cement is applied to the surfaces of the metal and is forced into the joint during the rolling process used for making the can.

4. The Manufacture of Dipped Goods

In making dipped goods, a form of wood, glass, porcelain, aluminum or a similar material is dipped into a rubber or a latex cement, lifted out and the adhering solution allowed to dry. This operation is repeated until the rubber coating reaches the desired thickness.

If a non-vulcanizing rubber or latex cement is used, the product may be vulcanized by dipping it into a 2% solution of sulphur chloride. (Carbon bi-sulphide is considered the best solvent for this purpose). The time required for vulcanization is from about 30 to 45 seconds. After vulcanization the product should be dipped in an ammonium hydroxide solution to neutralize the excess of sulphur chloride and check the vulcanizing before it has gone too far.

If a vulcanizing cement is used, the product may be vulcanized with heat. In general, products which are vulcanized with heat are apt to have better aging characteristics than those vulcanized with sulphur chloride.

The process of making dipped goods, although simple in principle, requires great care and attention to details in order to obtain a satisfactory product. The cement must be uniformly smooth and of the proper consistency. Dipping must be done with care, the drying process carried out at the proper rate and precautions taken to avoid any dirt or dust.

The manufacture of dipped goods from latex may be effected by electrodeposition. A brief description of this process and references to publications relating to it are given in Letter Circular LC 321 on Rubber Latex, which may be obtained without charge from the Bureau of Standards.

5. Rubberizing Fabrics

Rubber-coating of fabrics for use in the manufacture of products such as raincoats, balloons, sheeting, etc., is an important part of the rubber industry. The rubberizing is usually done by the spreading process. The untreated cloth is run from a roll into a spreading machine where rubber cement is distributed evenly over the surface by means of a spreader knife. The cloth is then passed over a hot plate to evaporate the solvent and then is re-rolled. It is passed through the machine as many times as may be necessary to obtain the desired thickness of rubber. If a non-vulcanizing cement is used, vulcanization is produced by passing the cloth through a chamber containing sulphur chloride vapor, after which it is neutralized to prevent "tendering" of the fabric. If a vulcanizing cement is used, the cloth may be vulcanized with heat by hanging in a heated chamber or by rolling it between liners and vulcanizing in steam.

If vulcanized latex is used for spreading, no vulcanizing treatment is necessary. This makes the process well adapted to use for silk, rayon, etc., to avoid damage to the fabric or injury to delicate colors.

VI. PRODUCTION OF RUBBER CEMENT ON A SMALL SCALE

Although various types of rubber cements can be purchased ready mixed, there are circumstances under which the individual may wish to prepare cements in lots ranging from a few ounces to a few gallons at a time. The first difficulty likely to be encountered is in the purchase of ingredients. These are available in only a few of the larger cities, and the dealers for the most part are accustomed to selling to manufacturers in large lots, rather than at retail in small lots. Such advice as can be offered regarding probable sources of supply is given in a subsequent section of this letter circular.

The second difficulty which may be met is in the milling or "breaking down" of the rubber. This requires the use of a rubber mill or internal mixer. As indicated in section II, this difficulty may be partly overcome with a solvent activator. It is not known whether there are any firms which regularly engage in the business of supplying milled, or "broken down" crude rubber in small lots, but many small firms are willing to mill occasional lots of rubber for a reasonable consideration. Some users obtain a sufficient supply of milled rubber to last for several months and make up cement in small lots as required.

The third difficulty which may be met is in the mixing of the cement. As indicated elsewhere this can be done by hand, but if large or frequent batches are required, hand mixing is apt to be tedious and time-consuming. Mechanical mixing can be accomplished by various laboratory mixing, stirring, or shaking devices, or by small dough mixers or churns which are designed along the same lines as the large scale commercial cement mixing equipment.

To offset these difficulties, there may be certain advantages in making rubber cement on a small scale. The uses of rubber cement are so multitudinous that there may be purposes which cannot be served as well by standard commercial cements as by a cement made up for the particular job. Furthermore, there may be cases where the characteristics desired for a cement cannot be specified in advance, but where it is necessary to "cut and try" until a product of optimum characteristics is obtained. Any development process such as this can often be best served if the investigator has in hand the necessary ingredients for a cement and can blend them in various proportions until the desired results are achieved. In still other cases it may be desirable to make rubber cement on a small scale for the reason that the cost of ingredients for making a cement may be much less than the price of the same product, ready-mixed, when purchased at retail.

VII. COMMERCIAL SOURCES OF MATERIALS

Following is a partial list of firms selling cements or dealing in materials used for making rubber cements. For further names, reference can be made to rubber trade journals such as the India Rubber World; Rubber Age; and India Rubber and Tire Review.

1. Rubber Cements

The following list of manufacturers of rubber cements has been taken from advertisements in rubber trade journals. Several different types of cements can be purchased ready for use.

E. I. du Pont de Nemours and Company, Fairfield, Conn.
(Also can supply "duprene" cement)
Essex Rubber Co., Trenton, N. J.
B. F. Goodrich Co., Akron, Ohio.
Gutta Percha & Rubber, Ltd., Toronto, Canada.
Linear Packing & Rubber Co., Philadelphia, Pa.
Schrader & Ehlers, 239 Fourth Avenue, New York, N. Y.
Rubber and Asbestos Corporation, Jersey City, N. J.
Montgomery Brothers, Philadelphia, Pa.
United States Rubber Co., 1790 Broadway, New York, N. Y.
Van Cleef Bros., Woodlawn Avenue & 77th Street, Chicago, Ill.
Dewey & Almy, Cambridge, Mass.

2. Rubber Latex and Latex Preparations

Chas. T. Wilson Co., Inc., 99 Wall Street, New York, N. Y.
Heveatex Corporation, 77 Goodyear Avenue, Melrose, Mass.
Naugatuck Chemical Co., 1790 Broadway, New York, N. Y.
Revertex Corporation of America, 40 Rector Street, New York, N. Y.
(This firm sells a concentrated latex called "revertex".)
Vultex Corporation of America, 666 Main Street, Cambridge, Mass.
(This firm is the only source of vulcanized latex in the United States.)

3. Crude Rubber

H. Muehlstein & Co., Inc., 41 East 42nd Street, New York, N.Y.
Chas. T. Wilson Co., Inc., 99 Wall Street, New York, N. Y.

We have been advised that the above two concerns are in a position to deliver crude rubber in small lots as well as in quantity.

Other dealers in crude rubber may be found by reference to rubber trade journals. Most crude rubber is supplied in bales weighing about 200 pounds.

4. Solvents

Gasoline suitable for rubber cements may be purchased from local dealers in many cities and from

Anderson, Prichard Oil Corporation, Oklahoma City, Okla.
William Cooper & Nephews, Inc.,
1909 Clifton Avenue, Chicago, Ill.
134 E. Miller Avenue, Akron, Ohio.

Benzol and carbon tetrachloride can be purchased at retail from many drug stores. They may also be obtained from chemical firms, wholesale drug firms, and laboratory supply houses.

5. Vulcanizing Ingredients

American Cyanamid & Chemical Corporation, 535 Fifth Avenue, New York, N. Y.
E. I. du Pont de Nemours & Co., Wilmington, Del.
Naugatuck Chemical Co., 1790 Broadway, New York, N. Y.
New Jersey Zinc Co., 160 Front Street, New York, N. Y.
R. T. Vanderbilt Co., 230 Park Avenue, New York, N. Y.
Rubber Service Laboratories, Akron, Ohio.

6. Mixing Machinery

American Tool & Machine Co., Hyde Park, Boston, Mass.
Baker Perkins Co., Saginaw, Mich.
The J. H. Day Co., Cincinnati, Ohio.
Farrel-Birmingham Co., Inc., Ansonia, Conn.
Chas. E. Francis Co., Rushville, Ind.

VIII. BIBLIOGRAPHY

Considerable information on rubber and latex cements is to be found in recent books and in current technical literature on rubber. There is, however, no single publication in which all of the available knowledge on the subject is summarized in a comprehensive manner.

Among books which may be consulted with profit regarding rubber cements are Gottlob's Technology of Rubber, English Translation, MacLaren and Sons, London, 1926, and Chemistry of Rubber by Lothar E. Weber, Chas. Griffin & Co., London, 1926. Two books which give a great deal of information about latex cements are Rubber Latex by E. A. Hauser, English Translation, by W. J. Kelly, The Chemical Catalog Co., New York, and Latex and Its Industrial Applications, by Frederick Marchianno, Rubber Age Publishing Co., New York.

Titles of other books may be found by consulting letter circular 305, A Guide to the Literature on Rubber, which may be obtained without charge on application to the Bureau of Standards.

A number of articles on rubber cements and latex cements have appeared in rubber journals and in other publications. A few of these are the following:

Rubber As An Adhesive, by J. J. Allen and J. E. Beyer, published in Symposium on Rubber, pp. 151-159, which is a collection of papers delivered at the Cleveland Regional Meeting of the American Society for Testing Materials, Cleveland, Ohio, March 9, 1932.

The Production of Rubber Solutions, India Rubber Journal, vol. 73, p. 671, April 23, 1927.

Rubber Latex, by V. M. Morris and H. W. Greenup, Industrial and Engineering Chemistry, vol. 24, p. 755, July 1932, also in Rubber Chemistry and Technology, vol. 5, No. 4, p. 469, October 1932. This is a general review of the actual and proposed uses for latex and products made from latex.

Rubber Cements and Adhesives, by S. D. Sutton, India Rubber World, October 1929, p. 58.

Rubber Cements, by S. D. Sutton, India Rubber World, p. 58, December 1929, and p. 58, January 1930.

Some Solutions and Dispersions Used in the Rubber Factory, by Frank A. Middleton, India Rubber Journal, vol. 85, p. 543, May 1933.

Conversion of Rubber into Thermo-plastic Products with Properties Similar to Gutta Percha, Balata and Shellac, by Harry L. Fisher, Industrial and Engineering Chemistry, vol. 19, p. 1325-33, December 1927.

Latest Applications of the Vulcalock Process to Industry, by H. E. Fritz, Rubber Age (New York), vol. 27, p. 587-8, September 10, 1930.

Uniting Rubber to Metals, India Rubber World, February 1929, p. 65, and p. 69, March 1929. These two articles describe different methods used and list patents on the subject.

Some information on rubber cements is also given in the Encyclopaedia Britannica under the heading "Rubber".